MARINE BIOTOXIN MONITORING PROGRAM

ANNUAL REPORT

2005

Submitted to:

California Department of Fish and Game

By:

California Department of Health Services

Division of Drinking Water and Environmental Management

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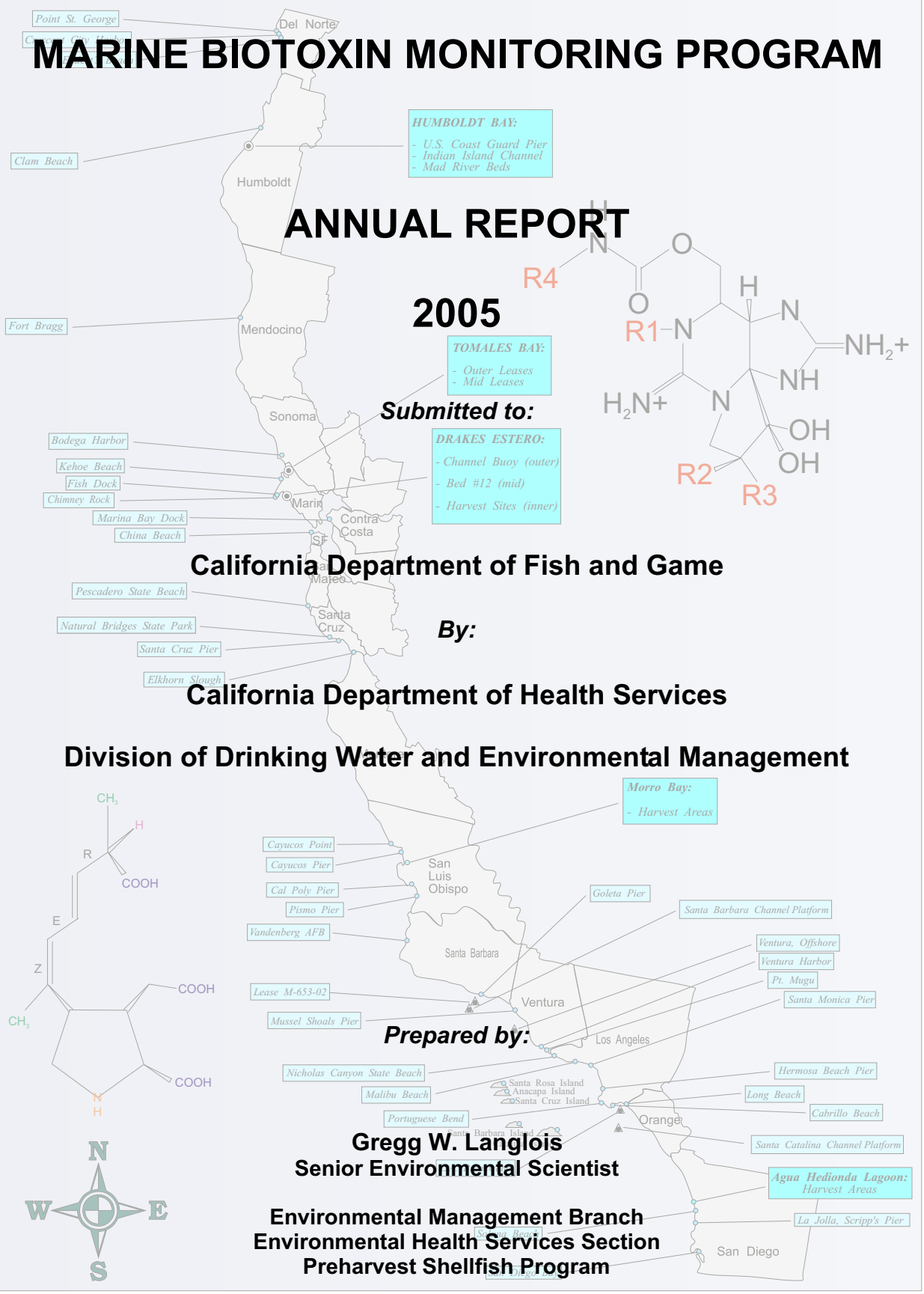

ACKNOWLEDGEMENTS

This report was prepared for the California Department of Fish and Game under agreement number PO170005. The California Department of Health Services would like to thank the Department of Fish and Game for their support of the paralytic shellfish poisoning monitoring portion of the marine biotoxin program.

The Department of Health Services' Marine Biotoxin Monitoring Program would also like to acknowledge the dedicated work of the staff of the Department's Microbial Diseases Laboratory and the Food and Drug Laboratory for their efforts in conducting PSP assays and domoic acid analyses, respectively. Due to the unpredictable nature of marine biotoxin activity, the laboratories are often called upon to respond immediately to the influx of samples that result from these events. It is due to their efforts that we are able to provide rapid feedback to field samplers and notify the public of potential health risks.

Shellfish toxicity data is generated on a regular basis by the Department of Health Services' Marine Biotoxin Monitoring Program thanks to the continuing efforts of our program participants. Additionally, volunteers are collecting phytoplankton samples on a routine basis and increase their frequency during periods of concern, providing near real-time observations of the occurrence of toxin producing species. As with all such endeavors, our success in protecting the public is due in large part to the numerous people who contribute their time and effort to collect samples at representative sites along the coast. The monthly listing of our program participants, provided in each monthly report, illustrates the diversity of groups and individuals that contribute to these efforts.

The Department of Health Services expresses its sincere appreciation to our program participants for all of their efforts. It is through their active participation that the Department is able to protect and improve the health of all Californians.

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INTRODUCTION

California has a long history of paralytic shellfish poisoning (PSP), dating back to the time of the coastal Native American tribes. According to Meyer (1928) it was a common procedure for the coastal Pomo tribe to place sentries to watch for luminescence in the waves, having apparently established a link between bioluminescence and mussel poisoning, both of which are caused by dinoflagellates in the phytoplankton. The long-standing concern of California's public health officials for protecting the public from PSP has been warranted, as there have been 542 reported illnesses including 39 deaths attributable to this toxin since 1927 (Price et al., 1991).

In the fall of 1991 another natural toxin was identified along the California coastline. Domoic acid, a neurotoxin of lower potency than the PSP toxins, has become of equal concern because the blooms of diatoms that produce this toxin have been of greater frequency and longer duration than most PSP events over the past 10 years. In addition, domoic acid has had dramatic impacts on marine mammal and seabird populations along the coast, raising the public's awareness of marine biotoxins in general.

Because PSP toxicity represents a serious ongoing public health threat that requires year-round attention, the California Department of Health Services (DHS) has implemented a prevention program that has traditionally been comprised of five basic elements: (1) a coastal shellfish monitoring program; (2) monitoring of commercial shellfish product; (3) an annual statewide quarantine on sport-harvested mussels (from May 1 through October 31); (4) mandatory reporting of disease cases; and (5) public information and education activities. In response to the occurrence of a new toxin, domoic acid, in the fall of 1991, DHS added a sixth element to the Marine Biotoxin Monitoring Program: phytoplankton monitoring. This latter monitoring effort was the first volunteer-based phytoplankton monitoring program in the U.S. This annual report describes the shellfish sampling element of the program for PSP toxins and domoic acid and the phytoplankton monitoring results during 2005. A summary is also provided for quarantine and health advisory activities.

Paralytic Shellfish Poisoning

PSP is an acute, sometimes fatal form of food poisoning that is associated with the consumption of bivalve molluscs that have fed on the toxin-producing dinoflagellate *Alexandrium catenella* (formerly *Protogonyaulax catenella* and *Gonyaulax catenella*). Eating shellfish that contain PSP toxins leads to an acute disturbance of the nervous system within a few minutes to a few hours. The PSP toxins are sodium channel blockers and thus inhibit neural transmission. Symptoms begin with tingling and numbness of the lips, tongue, and fingertips, followed by disturbed balance, lack of muscular coordination, slurred speech and difficulty in swallowing. In severe poisoning, complete muscular paralysis and death from asphyxiation can occur if breathing is not maintained by artificial means. There is no known antidote to the poison. Symptoms tend to resolve entirely in a day or two under proper medical care. Persons who

suspect they or others are experiencing PSP symptoms should immediately seek medical treatment.

The type and severity of symptoms depends on the amount of toxic shellfish consumed as well as the specific toxicity of the shellfish. Price et al. (1991) summarize the range of toxin dose responses as follows: 200 to 500 micrograms (µg) will cause at least minor symptoms, 500 to 2000 µg will cause moderate to severe symptoms, and toxin concentrations greater than 2000 µg will produce serious to lethal effects. It should be noted that exceptions exist and serious health effects have also been documented at much lower concentrations (100 to 400 µg). The federal alert level for PSP toxicity is 80 µg per 100 grams (g) of shellfish tissue, and the detection limit for the PSP bioassay is approximately 40 µg/100 g.

Alexandrium is normally absent or constitutes a minor component of the marine phytoplankton community along the California coast. Under favorable environmental conditions this dinoflagellate may undergo periods of rapid population growth, frequently referred to as a "bloom". The term "bloom" or "red tide" is misleading with respect to *Alexandrium* and the resultant PSP toxicity in shellfish. Visible blooms of *Alexandrium* are rarely seen along the California coast. Conversely, elevated levels of PSP toxins in shellfish can result from the presence of relatively low numbers of *Alexandrium* in the water.

The source of the dinoflagellates that provide the "seed" for such blooms is in question, but two likely scenarios are possible. First, resting cysts of *Alexandrium* in local sediments can, under favorable conditions, produce vegetative cells that can then reproduce both sexually and asexually, resulting in localized "hot spots" of PSP toxicity in shellfish. Second, this dinoflagellate may be transported in offshore warm water masses that can move onshore under certain environmental conditions. This advection process could potentially result in either a quick spike in PSP toxicity if the number of transported cells is high, or it may simply provide the cells necessary for a bloom to initiate. Regardless of the origins of the toxin-producing dinoflagellates, the general pattern has been for these blooms to be detected first along the open coast, occasionally followed by transport into bays and estuaries. The degree to which coastal phytoplankton blooms intrude into bays and estuaries is likely influenced in part by the orientation of the bay relative to coastal currents and by the extent of tidal mixing and transport that occurs inside the bay.

Domoic Acid

In October of 1991 the presence of another marine biotoxin was confirmed in California's coastal waters. Domoic acid toxicity, which can result in the condition called amnesic shellfish poisoning (ASP), was identified as the cause of death in a large number of brown pelicans and Brandt's cormorants in the Santa Cruz area of Monterey Bay. The birds had been feeding on schools of anchovies in the bay, which in turn had been feeding on a bloom of the diatom *Pseudo-nitzschia australis* (formerly *Nitzschia pseudoseriata*).

The only documented domoic acid event prior to 1991 was a serious episode in Prince Edward Island, eastern Canada, in 1987 in which three people died and over 100 people were made ill from the consumption of toxic mussels. Domoic acid is a neuroexcitatory amino acid that causes over-stimulation of certain nerves cells in the brain, with potentially permanent or fatal effects. Case studies of the Canadian episode indicated that the most common symptoms were gastrointestinal, followed by neurologic symptoms including headaches, loss of balance and/or dizziness, memory loss, varying degrees of confusion, disorientation, changes in the level of consciousness, and in some cases seizures (Teitelbaum, 1990; Perl et al., 1990).

Based on the rather small number of case histories available the following dose responses can be approximated while recognizing the overlap in ranges and symptoms: 27 to 75 µg/g may result in mild to moderate symptoms (gastrointestinal), 40 to 700 µg/g may result in moderate to severe neurologic symptoms, and domoic acid concentrations greater than 450 µg/g may result in severe neurologic symptoms and/or death.

Phytoplankton

There were no documented human health impacts from the 1991 Monterey Bay domoic acid episode, but the severity of the Canadian outbreak made it clear that continued monitoring for domoic acid would be necessary for public health protection. Because of the cost and time involved in running separate analyses for each toxin, in addition to the prospect that other known toxins may be present along the California coast, DHS began a volunteer-based phytoplankton monitoring program in 1993. The intent of this program was to develop a network of volunteer samplers and field observers that would allow the early detection of potentially toxigenic blooms. Early detection is key to mobilizing and focusing additional sampling and analytical resources for plankton, shellfish, and other species in the affected region. As a result of this volunteer effort DHS has been able to detect and track numerous harmful algal blooms, improving the capabilities for protecting public health.

2005 SAMPLING EFFORT

Paralytic Shellfish Poisoning

Shellfish samples were collected at 53 different sites along the coast of California in 2005 (Figures 1a and 1b). Several commercial growing areas had multiple sites representing different harvest areas. There were 1108 shellfish samples collected statewide for PSP toxin assay during 2005. The greatest number of samples (398) was collected at sites in Marin County (Table 1), with commercial shellfish aquaculture companies providing approximately 91% of the samples collected in this county. The majority of these (251) were contributed by Johnson Oyster Company in Drakes Estero, which samples four stations on at least a weekly basis. The large proportion of Marin

County sites is a reflection of both the number of commercial growers and the frequency of occurrence of PSP toxicity in this region.

Commercial shellfish growers accounted for 67% of all samples collected in 2005, followed by coastal county health departments and various state agencies (7% and 20%, respectively; Table 2). Several other program participants, including federal agencies and volunteers, provided valuable assistance by contributing their sampling effort in 2005. The diversity of participants is a valuable component of the monitoring program (Table 3). As mentioned above, monitoring of the outer coast is a key element in California's marine biotoxin monitoring program because all toxic blooms to date have originated offshore or along the coast. Monitoring coastal shellfish resources can therefore provide an early warning of toxic conditions that may soon impact shellfish in bays and estuaries, which harbor the majority of commercial shellfish growers and recreational clam beds.

The majority of samples collected in 2005 consisted of mussels (68%), followed by cultured pacific oysters (28%; Table 4). A variety of other species of shellfish were sampled for PSP toxin analysis in 2005, including rock scallops (*Crassadoma gigantea*), and several genera of clams. The Marine Biotoxin Monitoring Program continues to use mussels as a primary indicator species for PSP toxins because of their ability to bioaccumulate these toxins at a faster rate that other bivalve species (Shumway, 1990). Differential uptake in mussels versus oysters during a major PSP event in 1991 was previously documented (California Department of Health Services, 1991).

Domoic Acid

There were 181 shellfish samples analyzed for domoic acid during 2005 compared to 234 samples analyzed the previous year (Table 5). Samples from 42 different sampling sites were targeted for analysis as a result of observations from the volunteer monitoring network of high numbers of *Pseudo-nitzschia spp*. The greatest number of samples was submitted from Santa Barbara County (53) and San Luis Obispo County (40).

Phytoplankton

There were 1072 phytoplankton samples collected during 2005 at 126 sampling sites representing all coastal counties (Table 6). The greatest numbers of samples were collected in Marin (271), Los Angeles (183), Santa Barbara (160), and San Luis Obispo (133) counties. Samples were collected along all coastal counties by 71 volunteers (Figures 1c and 1d). Several areas (e.g., commercial shellfish growing areas) had multiple sites that are not individually identified in the figure and some volunteers may sample sites in multiple counties.

Of the 1072 phytoplankton samples collected in 2005, 451 (42%) contained at least one toxigenic species. Toxin-producing phytoplankton species were detected at 96 different sampling sites throughout all but one (Mendocino) of the15 coastal counties in 2005.

The greatest number of samples containing toxin-producing species was collected in Marin County (148), Santa Barbara County (107), San Luis Obispo County (87), and Los Angeles (72).

2005 RESULTS

Paralytic Shellfish Poisoning Toxicity and *Alexandrium* Observations

The geographic distribution and magnitude of PSP toxicity in 2005 was slightly less than observed in 2004 (Figure 2). However there were more samples above the alert level that were distributed throughout a greater number of counties than occurred in 2004. Measurable concentrations of PSP toxins were found in 241 shellfish samples from the following coastal counties: Sonoma, Marin, San Francisco, San Mateo, Santa Cruz, San Luis Obispo, Santa Barbara, Ventura, Los Angeles, and San Diego.

PSP toxins were detected as early as January along the San Luis Obispo coast and inside Monterey Bay near Santa Cruz. By late February the PSP toxin levels in mussels from San Luis Obispo had exceeded the alert level. Toxicity increased above the alert level.

PSP toxin concentrations at or above the alert level were detected in 32 samples from Sonoma (1), Marin (16), San Francisco (1), Santa Cruz (2), San Luis Obispo (3), Santa Barbara (8), and Ventura (1) counties. PSP toxicity was found most frequently, and at the highest concentrations, along the coast of Marin County during 2005. The highest concentration detected was 879 µg in mussels from a Drakes Bay sentinel mussel station.

PSP toxins were present at low levels in shellfish samples every month during 2005 except December. In general, the temporal distribution of PSP toxins was typical of the average annual pattern observed over the past 23 years (Figure 3). There was an unusual, persistent low level of toxicity detected in Santa Cruz and San Luis Obispo throughout January. There was a brief early spring increase in *Alexandrium* (Figure 4), with PSP toxins in shellfish increasing above the alert level of 80 micrograms (µg) per 100 grams of shellfish meat by February 20 in San Luis Obispo. Toxin levels decreased in March, then increased again in April and June for sites in Santa Barbara and Marin, respectively. The late June increase in PSP toxin concentration continued through the end of July. A final short-lived increase in toxicity occurred at the beginning of October at one site in Santa Barbara.

Following is an overview of *Alexandrium* and PSP toxin monitoring efforts during 2005. Detailed maps illustrating the weekly relative PSP toxin concentrations for each month, the monthly distribution and relative abundance of *Alexandrium* and *Pseudo-nitzschia*, and the monthly lists of program participants are provided in separate monthly reports. These reports are available at the following Internet site:

http://www.dhs.ca.gov/ps/ddwem/environmental/Shellfish/default.htm

Despite winter conditions the phytoplankton samples collected in January contained small numbers of *Alexandrium* at several Northern California sites. Low concentrations of PSP toxins were detected in mussels at several locations along the coast between Marin and Monterey. Detectable levels of these toxins persisted in mussels from Santa Cruz from January 12 through the end of the month.

Alexandrium was also observed inside Morro Bay (San Luis Obispo) during January, a continuation of a brief event in December 2004. However the cell numbers and geographic distribution of this dinoflagellate decreased compared to the December's observations. Low levels of PSP toxins continued to be detected at all sampling sites in San Luis Obispo County. It was not until the last week of the month that toxin concentrations inside Morro Bay dropped below the detection limit.

By February the abundance of *Alexandrium* increased significantly between Marin and San Luis Obispo counties. *Alexandrium* was common at two sites inside Monterey Bay, a rare occurrence in February. Low concentrations of PSP toxins were detected at several locations in this region. Detectable levels of these toxins persisted in mussels from Santa Cruz throughout the month. PSP toxin concentrations increased above the alert level in Morro Bay by February 20 (250 µg). Elevated levels of these toxins were detected through the end of the month inside Morro Bay (115 µg) and at Cayucos Point (109 µg).

Alexandrium distribution and relative abundance declined in Northern California but remained stable in the southern counties in March. Low concentrations of PSP toxins persisted at a number of locations between San Luis Obispo and Ventura counties. Of note was the detection of a low concentration of these toxins in the viscera of lobster caught near Anacapa Island on March 12.

PSP toxicity did not occur again in Northern California until April 27 when a very low level of these toxins was detected in at the sentinel mussel station in Drakes Bay (Marin County). In Southern California, however, the distribution and relative abundance of *Alexandrium* increased significantly during April. The highest cell numbers were observed at Pismo Pier and farther south at the Santa Barbara sites. Of particular interest was the observation of *Alexandrium* at two sites offshore of Los Angeles, including a site near Catalina Island. PSP toxicity increased significantly by the first week of April, exceeding the alert level on April 5 (101 µg) in mussels from a commercial aquaculture site approximately three-quarters of a mile offshore of Santa Barbara. The previous sample from this site, collected on March 31, contained only 45 µg). Given the rapid increase in toxin levels above the alert level within only five days it may be necessary for a seasonal batch release requirement to be imposed. PSP toxin levels continued to increase at this site through April 21 when the concentration reached 448 µg in mussels and 153 µg in oysters, respectively. Earlier in the month (April 7) a sample of rock scallop viscera was found to contain 185 µg of PSP toxins. Low levels of these toxins were also detected in mussels from nearshore sites in Santa Barbara, Ventura, and Los Angeles counties. PSP toxin levels decreased along the Santa

Barbara coast by April 26, remained low through May, and declined below the detection limit throughout June.

The distribution and relative abundance of *Alexandrium* began increasing in May in Northern California. The greatest relative abundance of this dinoflagellate was observed inside Drakes Bay (Marin County) by May 20. A low concentration of PSP toxins was detected at the sentinel mussel station in Drakes Bay by May 31. By the third week of June there were low levels of these toxins present in shellfish from Marin through Santa Cruz counties. PSP toxins increased above the alert level in sentinel mussels from Drakes Bay (132 µg) and Drakes Estero (155 µg) by the last week of June.

Alexandrium distribution and relative abundance continued to increase in July, particularly along coast between Bodega Bay (Sonoma County) and Monterey Bay. PSP toxin concentrations also continued to increase in the Drakes Bay region. The highest toxin concentrations detected were in sentinel mussels from Drakes Bay (879 ug) and Drakes Estero (616 µg). Toxin levels decreased below the alert level in Drakes Estero by July 25 but remained above the alert level at the Drakes Bay sentinel mussel station through early August. Toxin concentrations above the federal alert level were also detected at sites in San Francisco and Santa Cruz counties.

Observations of *Alexandrium* continued through August and September at various locations throughout the state, although relative abundances were generally low. Low levels of PSP toxins continued to be detected through September at sites in Marin and San Luis Obispo. By October there was a rapid increase in PSP toxicity in northern Santa Barbara County: a mussel sample collected from Vandenberg on October 1 contained 123 µg of PSP toxins. The previous samples collected from this site in August and September did not contain detectable levels of toxin. A subsequent sample of mussels from Vandenberg contained a low concentration (40 µg) of PSP toxins. There was also a slight increasing trend in toxin concentrations detected in mussels from Morro Bay during October, reaching 70 µg by October 30. Low concentrations of PSP toxins persisted along the Marin coast and increased inside Drakes Estero.

Alexandrium continued to be present in coastal waters through November and December. PSP toxicity increased to moderate levels in the Drakes Bay and Drakes Estero sentinel stations in early November (76 µg and 73 µg, respectively), but declined to low concentrations throughout the remainder of the month. Low concentrations of PSP toxins were also at other Marin sites as well as inside Morro Bay. By December there were no detectable levels of PSP toxins in shellfish samples. However low numbers of *Alexandrium* continued to be observed at various Northern California sites and at one Southern California site (Scripps Pier) in December.

Domoic Acid Toxicity and *Pseudo-nitzschia* Observations

Measurable concentrations of domoic acid were found in 40 samples during 2005, compared to 144 positive samples in 2004. Domoic acid was detected in samples from the following coastal counties: Del Norte, Humboldt, Santa Barbara, and Ventura.

Concentrations of domoic acid above the alert level (20 micrograms (µg) per gram of shellfish meat, or 20 parts per million (ppm)) were detected in 9 of the 40 positive samples from the following three counties: Del Norte, Santa Barbara, and Ventura. The highest concentration of domoic acid (290 ppm) was detected in a sample of lobster viscera collected near Anacapa Island. The highest level of this toxin found in bivalve shellfish was 42 ppm in mussels from Del Norte County.

The magnitude and temporal and geographic distribution of domoic acid toxicity in 2005 was reduced compared to 2004. *Pseudo-nitzschia* relative abundance increased briefly during the latter part of March and again in June. The highest percent compositions of this diatom were observed in October in Del Norte County and were associated with elevated levels of domoic acid in mussels. The percent composition of this diatom was high at several sites along the Santa Barbara coast in June (Figure 6), however the cell mass was not extremely high. Domoic acid levels increased in shellfish samples from sites in Santa Barbara at this time, but did not exceed the alert level. Elevated numbers of *Pseudo-nitzschia* were also observed offshore neat the Channel Islands. High concentrations of domoic acid were detected in lobster viscera samples from Anacapa, Santa Rosa, and Santa Cruz islands.

Under some circumstances the percent composition data for *Pseudo-nitzschia* can be misleading. To adjust for the importance of cell mass, as well as sampling effort, a Relative Abundance Index (RAI) was formulated. The RAI is based on an estimate of cell mass as determined by settled cell volume (a), the percent composition of each species (b), and the sampling effort as determined by the total tow length (c):

$$RAI = (a_{*}b)/c$$

The RAI data can provide perspective on the significance of the percent composition data for *Pseudo-nitzschia* or other species of interest. Many of the observations of high percent compositions of *Pseudo-nitzschia* (Figure 6) have less importance when the RAI is determined (Figure 7).

As discussed earlier, detailed accounts of toxigenic phytoplankton distribution and biotoxin concentrations can be found in the monthly reports. The following is a brief account of domoic acid and *Pseudo-nitzschia* activity during 2005.

Pseudo-nitzschia was observed along most of the California coast in January, however the relative abundance of this diatom was low. By February there was a noticeable increase in the abundance of this diatom at sites from Marin through Santa Cruz counties. This increase was short-lived and the relative abundance declined and remained low through March. Elevated levels of domoic acid were detected in January and February in lobster viscera samples collected offshore near the Channel Islands.

By April *Pseudo-nitzschia* was observed along most of the California coast. The relative abundance of this diatom increased slightly at nearshore sites in Humboldt and Santa Cruz counties, as well as in samples offshore of Sonoma and Marin counties and inside

San Francisco Bay. The greatest increases in the relative abundance of this diatom were observed at sites from San Luis Obispo to offshore of Los Angeles County. A very low level of domoic acid (1.5 ppm) was detected in oysters offshore of Santa Barbara on April 5.

The relative abundance of *Pseudo-nitzschia* increased along the Del Norte coast at Crescent City and offshore of the Sonoma coast in May. Low to moderate levels of domoic acid were detected at several sites near Crescent City. Mussels from Point St. George contained 3 ppm of this toxin on May 10 and less that 1 ppm by May 25. Razor clams from two different locations near Crescent City contained 13 ppm and 15 ppm of domoic acid on May 25 and May 27, respectively. It was uncertain if the moderate level of domoic acid in the razor clam samples was due to residual toxin from the previous event or if it represented recent increases due to the greater number of *Pseudo-nitzschia* observed in May. The relative abundance of this diatom decreased at most Southern California sites in May. Domoic acid was not detected in shellfish from Southern California sites during May.

Pseudo-nitzschia was observed at most sampling stations along the California coast in June. The relative abundance of this diatom increased at several sites inside Monterey Bay and at sites along the coast of San Luis Obispo and Santa Barbara counties. This diatom was also abundant offshore in samples from the Santa Barbara Channel and near Santa Cruz Island. *Pseudo-nitzschia* was also present in low numbers at sites along the Los Angeles coast and offshore near Catalina Island. Low levels of domoic acid continued to be detected at sites in Del Norte and Humboldt counties. Mussels from Point St. George contained 6 ppm and razor clams from Clam Beach contained 5 ppm of domoic acid by late June. Domoic acid was detected in low to moderate levels in shellfish from San Luis Obispo through Ventura counties. The highest concentrations of domoic acid were found in mussels and oysters (15 ppm each) from an aquaculture lease just offshore of Arroyo Burro Beach (Santa Barbara County). Samples of anchovies caught offshore of Ventura County were obtained by the CDHS Food and Drug Branch and found to contain extremely high concentrations of domoic acid (150 ppm). As a result of these high toxin levels a health advisory was issued as described in the section on quarantines and health advisories.

The percent composition of *Pseudo-nitzschia* remained high through July, however the RAI declined through the month. With the exception of low levels of domoic acid (4.2 ppm) in razor clams from Clam Beach (Humboldt County) in July, domoic acid continued to be absent from samples collected along the coast. Unfortunately shellfish samples were not available from those locations with the highest abundances of this toxic diatom. *Pseudo-nitzschia* decreased in relative abundance at most Southern California locations. Low numbers of this diatom were observed offshore of Santa Rosa, Catalina, and San Nicolas islands.

By October the relative abundance of *Pseudo-nitzschia* increased at sites in Santa Cruz, Humboldt, and Del Norte counties. The highest relative abundances of this diatom were observed inside Humboldt Bay and at Crescent City. A high concentration of

domoic acid (42 ppm) was detected in a mussel sample from Point St. George (Del Norte County) on October 17. Increased numbers of this diatom were observed offshore of Santa Rosa Island by October 4, decreasing by the end of the month. High concentrations of domoic acid were detected in lobster viscera samples from sites around the Channel Islands throughout October. The highest concentration detected was 290 ppm in a sample collected near Anacapa Island on October 2. Concentrations of this toxin remained high at this site through the end of the month (154 ppm on October 29). This toxin was mostly absent from nearshore samples, supporting the phytoplankton observations that indicated an offshore bloom with no major transport to the nearshore area. Domoic acid was not detected in the muscle tissue of the lobsters containing high toxin levels in the viscera. DHS would like to thank members of the National Park Service and volunteer Bill Weinerth for their tremendous assistance in providing these valuable samples from the Channel Islands.

Pseudo-nitzschia continued to be present at various sites along the California coast but relative abundances were greatly reduced throughout November and December. This diatom was abundant offshore near Santa Barbara Island on November 19 and was still observed offshore near Santa Rosa Island in December.

2005 PSP QUARANTINES AND RELATED HEALTH ADVISORIES

The annual quarantine on the sport-harvesting of mussels went into effect on May 1 as scheduled. The annual mussel quarantine applies only to sport-harvested mussels along the entire California coastline, including all bays and estuaries. Routine biotoxin monitoring is maintained throughout this period. The annual quarantine does not affect the certified commercial shellfish growing areas in California.

On June 24 the State Health Director issued a health advisory warning the public not to eat mussels or the viscera of sardines, anchovies, lobster (also known as lobster “tomale”), and crab (sometimes called crab “butter”) from Ventura County. This advisory was issued after dangerous levels of domoic acid were detected in anchovies from this region, which increased the likelihood of this toxin being present in the other seafood items listed.

The annual quarantine on the sport-harvesting of mussels was rescinded on midnight, October 31, as scheduled.

There were no reported human illnesses or deaths due to PSP or domoic acid poisoning in 2005.

REFERENCES

California Department of Health Services Marine Biotoxin Monitoring Program, 1991. "Shellfish biotoxin monitoring program annual report, 1991", 50 pp.

Meyer, K.F.; Sommer, H.; Schoenholz, P. 1928. "Mussel Poisoning", J. Prevent. Medicine, 2:365 – 394.

Perl, T.M.; Bedard, L.; Kosatsky, T. Hockin, J.C.; Todd, E.C.D.; McNutt, L.A.; Remis, R.S. 1990. "Amnesic shellfish poisoning: a new clinical syndrome due to domoic acid", In: "Proceedings of a Symposium, Domoic Acid Toxicity", Canada Diseases Weekly Report, Vol. 16S1E, 123 pp.

Price, D.W.; Kizer, K.W.; Hansgen, K.H. 1991. "California's paralytic shellfish poisoning prevention program, 1927 – 89", *J. Shellfish Res.*, 10:119 -145.

Shumway, S. E. 1990. "A review of the effects of algal blooms on shellfish and aquaculture", J. World Aquaculture Soc., 21: 65 – 104.

Teitelbaum, J. 1990. "Acute manifestations of domoic acid poisoning: Case presentations", In: "Proceedings of a Symposium, Domoic Acid Toxicity", Canada Diseases Weekly Report, Vol. 16S1E, 123 pp.

TABLES 1 – 8

Table 1. Total number of shellfish samples collected per coastal county in 2005 for PSP assay.

COUNTY	# SAMPLES
Del Norte	17
Humboldt	102
Mendocino	1
Sonoma	4
Marin	398
Contra Costa	1
San Francisco	6
San Mateo	16
Santa Cruz	58
Monterey	0
San Luis Obispo	155
Santa Barbara	174
Ventura	26
Los Angeles	40
Orange	1
San Diego	109
TOTAL	**1108**

Table 2. Number of shellfish samples collected by program participants, per coastal county, in 2005 for PSP assay.

COUNTY (North to South)	COMMERCIAL GROWERS	COUNTY AGENCIES	STATE AGENCIES	FEDERAL AGENCIES	OTHER PARTICIPANTS	TOTAL
Del Norte	--	14	3	--		17
Humboldt	100			--	2	102
Mendocino	--	1	--	--	--	1
Sonoma	--	--	4	--		4
Marin	363	--	35	--		398
Contra Costa			1			1
San Francisco	--	6	--	--	--	6
San Mateo	--	16	--	--	--	16
Santa Cruz	--	10	48	--	--	58
Monterey	--	--	--	--	--	0
San Luis Obispo	123	--	26	--	6	155
Santa Barbara	113	--	49	10	2	174
Ventura	--	10	--	3	13	26
Los Angeles	--	22	3	--	15	40
Orange	--	--	--	--	1	1
San Diego	43	--	50	12	4	109
TOTAL =	**742**	**79**	**219**	**25**	**43**	**1108**

Table 3. Program participants by county that submitted shellfish samples in 2005 for PSP assay.

COUNTY	AGENCY
Del Norte	Del Norte County Health Department
	U.C. Sea Grant Extension
Humboldt	Coast Seafoods Company
	DHS Volunteer
Mendocino	Mendocino County Environmental Health Department
Sonoma	California Department of Fish and Game
	DHS Marine Biotoxin Monitoring Program
Marin	Johnson Oyster Company
	Cove Mussel Company
	Hog Island Oyster Company
	Marin Oyster Company
	DHS Marine Biotoxin Monitoring Program
	Calif. Program for Regional Enhanced Monitoring of PhycoToxins
San Francisco	San Francisco County Health Department
San Mateo	San Mateo County Environmental Health Department
Santa Cruz	Santa Cruz County Environmental Health Department
	University of California Santa Cruz
	Calif. Program for Regional Enhanced Monitoring of PhycoToxins
Monterey	None Submitted
San Luis Obispo	Williams Shellfish Company
	Tomales Bay Oyster Company
	University of California Santa Barbara Marine Science Institute
	DHS Volunteer
	Morro Bay National Estuary Program
	Calif. Program for Regional Enhanced Monitoring of PhycoToxins
Santa Barbara	University of California Santa Barbara
	California Department of Parks and Recreation
	Vandenberg Air Force Base, Environmental Health Services
	Santa Barbara Mariculture Company
	DHS Volunteer
	National Park Service
Ventura	Ventura County Environmental Health Department

	DHS Volunteer
	National Park Service
	Naval Air Station, Pt. Mugu
Los Angeles	Los Angeles County Health Department
	Aquarium of the Pacific Long Beach
	Los Angeles Regional Water Quality Control Board
	University of Southern California Marine Lab
Orange	Aquarium of the Pacific Long Beach
San Diego	Carlsbad Aquafarm, Inc.
	DHS Volunteer
	Scripps Institute of Oceanography
	U.S. Navy

Table 4. Number and species of samples collected in 2005 for PSP assay.

SAMPLE TYPE	# SAMPLES
Bay Mussels[1]:	
Sentinel	130
Wild	23
Cultured	183
Total Bay Mussels	***336***
Sea Mussels[2]:	
Sentinel	176
Wild	191
Total Sea Mussels	***367***
Mixed Bay and Sea Mussels	49
Total Mussels	**752**
Pacific Oysters[3]	
Cultured	**316**
Rock Scallops	**9**
Other[4]	**31**
TOTAL	**1108**

[1] *Mytilus edulis or M. galloprovincialis*
[2] *Mytilus californianus*
[3] *Crassostrea gigas*
[4] *Washington clam, Razor clam, Gaper clam, Littleneck clam, Spiny Lobster, Sardine, Dungeness crab*

Table 5. Total number of shellfish samples analyzed for domoic acid, per coastal county, in 2005.

COUNTY	# SAMPLES
Del Norte	8
Humboldt	22
Mendocino	0
Sonoma	0
Marin	6
San Francisco	1
San Mateo	0
Santa Cruz	14
Monterey	0
San Luis Obispo	40
Santa Barbara	53
Ventura	22
Los Angeles	14
Orange	1
San Diego	0
TOTAL	**181**

Table 6. Total number of phytoplankton samples collected per coastal county in 2005.

COUNTY	# SAMPLES
Del Norte	33
Humboldt	70
Mendocino	3
Sonoma	18
Marin	271
Contra Costa	3
San Francisco	36
San Mateo	22
Santa Cruz	103
Monterey	20
San Luis Obispo	133
Santa Barbara	160
Ventura	23
Los Angeles	183
Orange	15
San Diego	85
TOTAL	**1072**

Table 7. Date and location of shellfish samples containing detectable levels of PSP toxins during 2005.

DATE	COUNTY	SAMPLE TYPE	SAMPLE SITE	PSP TOXINS (ug/100 g)
JANUARY				
01/07/05	San Luis Obispo	Bay Mussel, wild	Morro Bay, Boat Launch	44
01/10/05	San Luis Obispo	Sea Mussel, wild	Pismo Pier	39
01/12/05	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	43
01/14/05	San Luis Obispo	Bay Mussel, Sentinel	Morro Bay, WQ Station #12	37
01/18/05	San Luis Obispo	Sea Mussel, wild	Cayucos Pier	39
01/19/05	Santa Cruz	Sea Mussel, wild	Santa Cruz Pier	38
01/22/05	San Luis Obispo	Bay Mussel, Sentinel	Morro Bay, WQ Station #12	39
01/26/05	Santa Cruz	Sea Mussel, wild	Santa Cruz Pier	38
FEBRUARY				
02/02/05	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	51
02/07/05	Santa Cruz	Sea Mussel, wild	Natural Bridges	43
02/09/05	Santa Cruz	Sea Mussel, wild	Santa Cruz Pier	44
02/11/05	San Luis Obispo	Bay Mussel, Sentinel	Morro Bay, WQ Station #12	53
02/15/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	42
02/15/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #13	41
02/15/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	36
02/16/05	Santa Cruz	Bay Mussel, Sentinel	Santa Cruz Pier	72
02/17/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #13	41
02/17/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #38	42
02/17/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	46
02/20/05	San Luis Obispo	Pacific Oyster, cultured	Morro Bay, WQ Station #12	44
02/20/05	San Luis Obispo	Bay Mussel, cultured	Morro Bay, WQ Station #12	250
02/22/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #9	47
02/22/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	55
02/23/05	San Luis Obispo	Sea Mussel, wild	Cayucos Pier	36
02/23/05	San Luis Obispo	Pacific Oyster, cultured	Morro Bay, WQ Station #12	44
02/23/05	San Luis Obispo	Bay Mussel, Sentinel	Morro Bay, WQ Station #12	58
02/23/05	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	36

02/24/05	Marin	Sea Mussel, Sentinel	Drakes Bay, Chimney Rock LBS	46
02/24/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #12	36
02/24/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	39
02/26/05	San Luis Obispo	Pacific Oyster, cultured	Morro Bay, WQ Station #12	44
02/26/05	San Luis Obispo	Bay Mussel, Sentinel	Morro Bay, WQ Station #12	115
02/28/05	San Luis Obispo	Sea Mussel, wild	Cayucos Point	109
MARCH				
03/01/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	37
03/05/05	San Luis Obispo	Bay Mussel, cultured	Morro Bay, WQ Station #12	48
03/08/05	Santa Cruz	Sea Mussel, wild	Natural Bridges	39
03/08/05	San Luis Obispo	Sea Mussel, wild	San Luis Obispo, Cal Poly Pier	36
03/12/05	San Luis Obispo	Bay Mussel, cultured	Morro Bay, WQ Station #12	51
03/12/05	Ventura	Lobster, Spiny, viscera	Ventura, Anacapa Is., Mid	37
03/22/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	35
03/25/05	San Luis Obispo	Bay Mussel, cultured	Morro Bay	36
03/31/05	Santa Barbara	Pacific Oyster, cultured	Santa Barbara Ch., M-653-02	38
03/31/05	Santa Barbara	Bay Mussel, cultured	Santa Barbara Ch., M-653-02	45
APRIL				
04/05/05	Santa Barbara	Pacific Oyster, cultured	Santa Barbara Ch., M-653-02	48
04/05/05	Santa Barbara	Bay Mussel, cultured	Santa Barbara Ch., M-653-02	101
04/06/05	Santa Barbara	Sea Mussel, wild	Goleta Pier	36
04/07/05	Santa Barbara	Pacific Oyster, cultured	Santa Barbara Ch., M-653-02	55
04/07/05	Santa Barbara	Bay Mussel, Sentinel	Santa Barbara Ch., M-653-02	114
04/07/05	Santa Barbara	Rock Scallop, wild	Santa Barbara Ch., M-653-02	185
04/12/05	Santa Barbara	Pacific Oyster, cultured	Santa Barbara Ch., M-653-02	38
04/12/05	Santa Barbara	Rock Scallop, wild	Santa Barbara Ch., M-653-02	58
04/12/05	Santa Barbara	Bay Mussel, cultured	Santa Barbara Ch., M-653-02	83
04/13/05	Santa Barbara	Sea Mussel, wild	Goleta Pier	48
04/14/05	Los Angeles	Mixed Sea/Bay Mussels	Portuguese Bend	38
04/14/05	Santa Barbara	Pacific Oyster, cultured	Santa Barbara Ch., M-653-02	54
04/14/05	Santa Barbara	Bay Mussel, cultured	Santa Barbara Ch., M-653-02	191
04/18/05	Santa Barbara	Pacific Oyster, cultured	Santa Barbara Ch., M-653-02	54

04/18/05	Santa Barbara	Bay Mussel, cultured	Santa Barbara Ch., M-653-02	175
04/20/05	Santa Barbara	Sea Mussel, wild	Goleta Pier	78
04/21/05	Santa Barbara	Bay Mussel, cultured	Santa Barbara Ch., M-653-02	448
04/22/05	Santa Barbara	Pacific Oyster, cultured	Santa Barbara Ch., M-653-02	153
04/26/05	Santa Barbara	Bay Mussel, cultured	Santa Barbara Ch., M-653-02	43
04/26/05	Santa Barbara	Pacific Oyster, cultured	Santa Barbara Ch., M-653-02	54
04/27/05	Marin	Sea Mussel, Sentinel	Drakes Bay, Chimney Rock LBS	36
04/27/05	Santa Barbara	Sea Mussel, wild	Goleta Pier	41
04/27/05	Ventura	Sea Mussel, wild	Mussel Shoals, Oil Piers	49
04/30/05	Santa Barbara	Bay Mussel, cultured	Santa Barbara Ch., M-653-02	63
MAY				
05/04/05	Santa Barbara	Pacific Oyster, cultured	Santa Barbara Ch., M-653-02	40
05/04/05	Santa Barbara	Bay Mussel, cultured	Santa Barbara Ch., M-653-02	59
05/05/05	Santa Barbara	Sea Mussel, wild	Goleta Pier	39
05/11/05	Santa Barbara	Mixed Sea/Bay Mussels	Goleta Pier	42
05/18/05	Santa Barbara	Mixed Sea/Bay Mussels	Goleta Pier	36
05/26/05	Los Angeles	Sea Mussel, wild	Portuguese Bend	35
05/31/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	38
JUNE				
06/01/05	Santa Cruz	Sea Mussel, wild	Santa Cruz Pier	43
06/02/05	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	37
06/08/05	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	44
06/08/05	Santa Cruz	Sea Mussel, wild	Santa Cruz Pier	46
06/14/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	39
06/14/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	41
06/15/05	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	63
06/15/05	Santa Cruz	Sea Mussel, wild	Santa Cruz Pier	45
06/21/05	Marin	Pacific Oyster, cultured	Drakes Estero	39
06/21/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #12	37
06/21/05	Marin	Bay Mussel, wild	Drakes Estero, Bed #12	70
06/21/05	Marin	Bay Mussel, wild	Drakes Estero, Channel Buoy	43
06/21/05	San Mateo	Sea Mussel, wild	Pescadero State Beach	40

06/22/05	San Francisco	Sea Mussel, wild	China Beach	45
06/22/05	Marin	Sea Mussel, Sentinel	Drakes Bay, Chimney Rock LBS	51
06/22/05	Santa Cruz	Sea Mussel, wild	Santa Cruz Pier	60
06/23/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #12	36
06/23/05	Marin	Bay Mussel, cultured	Drakes Estero, Bed #12	51
06/23/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #40	40
06/23/05	Marin	Bay Mussel, cultured	Drakes Estero, Channel Buoy	88
06/27/05	Marin	Pacific Oyster, cultured	Drakes Estero	38
06/27/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #12	41
06/27/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	52
06/27/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	155
06/28/05	Marin	Sea Mussel, wild	Kehoe Beach	48
06/29/05	Marin	Sea Mussel, Sentinel	Drakes Bay, Chimney Rock LBS	132
06/29/05	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	41
06/29/05	Santa Cruz	Sea Mussel, wild	Santa Cruz Pier	57
JULY				
07/01/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #12	56
07/01/05	Marin	Bay Mussel, cultured	Drakes Estero, Bed #12	394
07/01/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #38	43
07/01/05	Marin	Bay Mussel, cultured	Drakes Estero, Channel Buoy	616
07/05/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #12	38
07/05/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	111
07/05/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #38	48
07/05/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	130
07/06/05	Marin	Sea Mussel, Sentinel	Drakes Bay, Chimney Rock LBS	400
07/06/05	Santa Cruz	Sea Mussel, wild	Santa Cruz Pier	165
07/06/05	Marin	Pacific Oyster, cultured	Tomales Bay, Lease #M430-02	37
07/07/05	San Francisco	Sea Mussel, wild	China Beach	44
07/07/05	San Mateo	Pacific Oyster, cultured	Pescadero State Beach	35
07/08/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #12	42
07/08/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	118
07/08/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	37

07/12/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #12	35
07/12/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	50
07/12/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #38	38
07/12/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	51
07/13/05	Marin	Sea Mussel, Sentinel	Drakes Bay, Chimney Rock LBS	157
07/14/05	Santa Barbara	Pacific Oyster, cultured	Santa Barbara Ch., M-653-02	39
07/15/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	36
07/15/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #38	40
07/19/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #12	48
07/19/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	134
07/19/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #4	40
07/19/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	248
07/20/05	Marin	Sea Mussel, Sentinel	Drakes Bay, Chimney Rock LBS	879
07/20/05	Santa Cruz	Sea Mussel, wild	Santa Cruz Pier	232
07/21/05	San Francisco	Sea Mussel, wild	China Beach	85
07/22/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #12	37
07/22/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	72
07/22/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #38	42
07/22/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	304
07/22/05	Marin	Pacific Oyster, cultured	Tomales Bay, Lease #M430-11	37
07/25/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	40
07/25/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	65
07/25/05	Ventura	Sea Mussel, wild	Mussel Shoals, Oil Piers	37
07/26/05	Sonoma	Sea Mussel, Sentinel	Bodega Harbor, USCG Dock	58
07/26/05	Sonoma	Sea Mussel, Sentinel	Bodega Harbor, USCG Dock	83
07/27/05	Marin	Sea Mussel, Sentinel	Drakes Bay, Chimney Rock LBS	151
07/27/05	Marin	Sea Mussel, Sentinel	Drakes Bay, Chimney Rock LBS	185
07/27/05	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	43
07/28/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	40
07/28/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	49
AUGUST				
08/02/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	38

08/02/05	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	44
08/03/05	Marin	Sea Mussel, Sentinel	Drakes Bay, Chimney Rock LBS	70
08/05/05	Santa Cruz	Sea Mussel, wild	Natural Bridges	35
08/08/05	Marin	Sea Mussel, Sentinel	Drakes Bay, Chimney Rock LBS	70
08/09/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	39
08/09/05	San Luis Obispo	Bay Mussel, cultured	Morro Bay, WQ Station #12	35
08/09/05	Santa Barbara	Rock Scallop, wild	Santa Barbara Ch., M-653-02	42
08/10/05	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	46
08/16/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	38
08/16/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #38	37
08/16/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	47
08/17/05	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	56
08/17/05	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	50
08/18/05	Santa Barbara	Rock Scallop, wild	Santa Barbara Ch., M-653-02	44
08/22/05	San Luis Obispo	Bay Mussel, cultured	Morro Bay, WQ Station #12	39
08/23/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	40
08/23/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	38
08/24/05	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	46
08/26/05	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	40
08/28/05	San Luis Obispo	Bay Mussel, cultured	Morro Bay, WQ Station #12	41
08/30/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	42
08/31/05	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	74
08/31/05	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	39
SEPTEMBER				
09/03/05	San Luis Obispo	Bay Mussel, cultured	Morro Bay, WQ Station #12	35
09/06/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	35
09/14/05	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	40
09/14/05	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	47
09/19/05	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	40
09/20/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	36
09/20/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	37
09/21/05	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	42

09/26/05	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	38
09/26/05	San Luis Obispo	Bay Mussel, cultured	Morro Bay, WQ Station #12	35
09/27/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	35
09/28/05	Santa Barbara	Rock Scallop, wild	Santa Barbara Ch., Plt. Holly	48
09/28/05	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	36
OCTOBER				
10/01/05	Santa Barbara	Sea Mussel, wild	Vandenberg AFB, Boathouse Dock	123
10/02/05	Ventura	Lobster, Spiny, viscera	Ventura, Anacapa Is., Mid	36
10/03/05	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	35
10/11/05	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	37
10/11/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	36
10/11/05	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	39
10/17/05	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	39
10/18/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	36
10/18/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #12	36
10/18/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	42
10/18/05	San Mateo	Sea Mussel, wild	Pescadero State Beach	39
10/19/05	San Luis Obispo	Sea Mussel, Sentinel	Morro Bay, Lease M-614-01 P2	36
10/19/05	Santa Cruz	Sea Mussel, Sentinel	Santa Cruz Pier	38
10/24/05	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	40
10/24/05	Marin	Pacific Oyster, cultured	Tomales Bay, Lease #M430-02	40
10/25/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #12	39
10/25/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	50
10/25/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #7	36
10/25/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	41
10/25/05	San Luis Obispo	Sea Mussel, Sentinel	San Luis Obispo, Cal Poly Pier	39
10/26/05	San Luis Obispo	Pacific Oyster, cultured	Morro Bay, Lease M-614-01 P2	39
10/26/05	San Luis Obispo	Bay Mussel, cultured	Morro Bay, Lease M-614-01 P2	44
10/26/05	Santa Cruz	Sea Mussel, wild	Santa Cruz Pier	36
10/27/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #12	47
10/27/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	53

10/27/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #7	43
10/27/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	63
10/29/05	Ventura	Lobster, Spiny, viscera	Ventura, Anacapa Is., Mid	35
10/30/05	San Luis Obispo	Bay Mussel, cultured	Morro Bay, WQ Station #11A	70
NOVEMBER				
11/01/05	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	76
11/01/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #12	42
11/01/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	52
11/01/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #38	42
11/01/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	73
11/01/05	Marin	Sea Mussel, wild	Kehoe Beach	65
11/02/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #12	40
11/02/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	51
11/02/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #38	39
11/02/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	60
11/02/05	San Mateo	Sea Mussel, wild	Pescadero State Beach	44
11/02/05	Santa Barbara	Sea Mussel, wild	Vandenberg AFB, Boathouse Dock	40
11/03/05	San Luis Obispo	Pacific Oyster, cultured	Morro Bay, Lease M-614-01 P2	36
11/03/05	San Luis Obispo	Bay Mussel, wild	Morro Bay, Lease M-614-01 P2	44
11/04/05	San Luis Obispo	Bay Mussel, cultured	Morro Bay, WQ Station #11A	36
11/05/05	Marin	Pacific Oyster, cultured	Tomales Bay, Lease #M430-11	42
11/08/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	38
11/08/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #12	40
11/08/05	Marin	Pacific Oyster, cultured	Drakes Estero, Bed #38	39
11/08/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	46
11/10/05	San Luis Obispo	Bay Mussel, Sentinel	Morro Bay, Lease M-614-01 P2	34
11/14/05	Marin	Sea Mussel, Sentinel	Drakes Bay, Fish Dock	39
11/15/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Bed #12	43
11/15/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	37
11/16/05	San Luis Obispo	Sea Mussel, wild	Cayucos Point	35
11/19/05	San Luis Obispo	Bay Mussel, cultured	Morro Bay, WQ Station #11	38

11/23/05	Marin	Bay Mussel, Sentinel	Drakes Estero, Channel Buoy	36
DECEMBER				
none				

Table 8. Date and location of shellfish samples containing detectable levels of domoic acid during 2005.

DATE	COUNTY	SAMPLE TYPE	SAMPLE SITE	DA (ppm)
JANUARY				
01/16/05	Ventura	Lobster, Spiny, viscera	Ventura, Anacapa Is., Mid	43
FEBRUARY				
02/26/05	Ventura	Lobster, Spiny, viscera	Ventura, Anacapa Is., Mid	31
MARCH				
APRIL				
04/05/05	Santa Barbara	Pacific Oyster, cultured	Santa Barbara Ch., M-653-02	1.5
MAY				
05/10/05	Del Norte	Sea Mussel, wild	Point St. George	3
05/25/05	Del Norte	Clam, razor	Crescent City Harbor	13
05/27/05	Del Norte	Clam, razor	Crescent City, Pier	15
JUNE				
06/02/05	Santa Barbara	Pacific Oyster, cultured	Santa Barbara Ch., M-653-02	1.8
06/02/05	Santa Barbara	Bay Mussel, cultured	Santa Barbara Ch., M-653-02	6.6
06/08/05	Santa Barbara	Mixed Sea/Bay Mussels	Goleta Pier	3
06/09/05	Santa Barbara	Bay Mussel, cultured	Santa Barbara Ch., M-653-02	2.1
06/09/05	Santa Barbara	Pacific Oyster, cultured	Santa Barbara Ch., M-653-02	5.7
06/15/05	Santa Barbara	Bay Mussel, cultured	Santa Barbara Ch., M-653-02	5.1
06/15/05	Santa Barbara	Pacific Oyster, cultured	Santa Barbara Ch., M-653-02	7.7
06/16/05	Santa Barbara	Bay Mussel, cultured	Santa Barbara Ch., M-653-02	7.2
06/16/05	Santa Barbara	Pacific Oyster, cultured	Santa Barbara Ch., M-653-02	15
06/20/05	Humboldt	Clam, razor	Humboldt, Clam Beach	5.5
06/21/05	Santa Barbara	Pacific Oyster, cultured	Santa Barbara Ch., M-653-02	6.1
06/23/05	Del Norte	Sea Mussel, wild	Point St. George	6.2
06/23/05	Santa Barbara	Bay Mussel, cultured	Santa Barbara Ch., M-653-02	5
06/23/05	Santa Barbara	Pacific Oyster, cultured	Santa Barbara Ch., M-653-02	5.2

06/25/05	Ventura	Sea Mussel, wild	Ventura Harbor	1.7
06/25/05	Ventura	Sardine, whole	Ventura Harbor	11
06/27/05	Santa Barbara	Sea Mussel, wild	Goleta Pier	7.8
06/27/05	Santa Barbara	Pacific Oyster, cultured	Santa Barbara Ch., M-653-02	9.1
06/27/05	Santa Barbara	Bay Mussel, cultured	Santa Barbara Ch., M-653-02	11
06/29/05	Santa Barbara	Sea Mussel, wild	Goleta Pier	3.7
06/29/05	Santa Barbara	Pacific Oyster, cultured	Santa Barbara Ch., M-653-02	14
06/29/05	Santa Barbara	Bay Mussel, cultured	Santa Barbara Ch., M-653-02	15
06/30/05	Santa Barbara	Pacific Oyster, cultured	Santa Barbara Ch., M-653-02	6
06/30/05	Santa Barbara	Bay Mussel, cultured	Santa Barbara Ch., M-653-02	6.7
JULY				
07/07/05	Humboldt	Clam, razor	Humboldt, Clam Beach	4.2
AUGUST				
SEPTEMBER				
OCTOBER				
10/02/05	Ventura	Lobster, Spiny, viscera	Ventura, Anacapa Is., Mid	290
10/13/05	Ventura	Lobster, Spiny, viscera	Santa Cruz Island	77
10/17/05	Del Norte	Sea Mussel, wild	Point St. George	42
10/21/05	Ventura	Lobster, Spiny, viscera	Santa Cruz Island	37
10/21/05	Ventura	Lobster, Spiny, viscera	Santa Cruz Island	48
10/25/05	Humboldt	Sea Mussel, Sentinel	Humboldt Bay, Indian Is. Ch.	1.1
10/25/05	Humboldt	Sea Mussel, Sentinel	Humboldt Bay, USCG Station	2.8
10/26/05	Santa Barbara	Lobster, Spiny, viscera	Santa Rosa Island	230
10/29/05	Ventura	Lobster, Spiny, viscera	Ventura, Anacapa Is., Mid	154
NOVEMBER				
DECEMBER				

FIGURES 1 – 13.

Figure 1a. Locations of shellfish sampling stations during 2005 (Del Norte to Monterey counties).

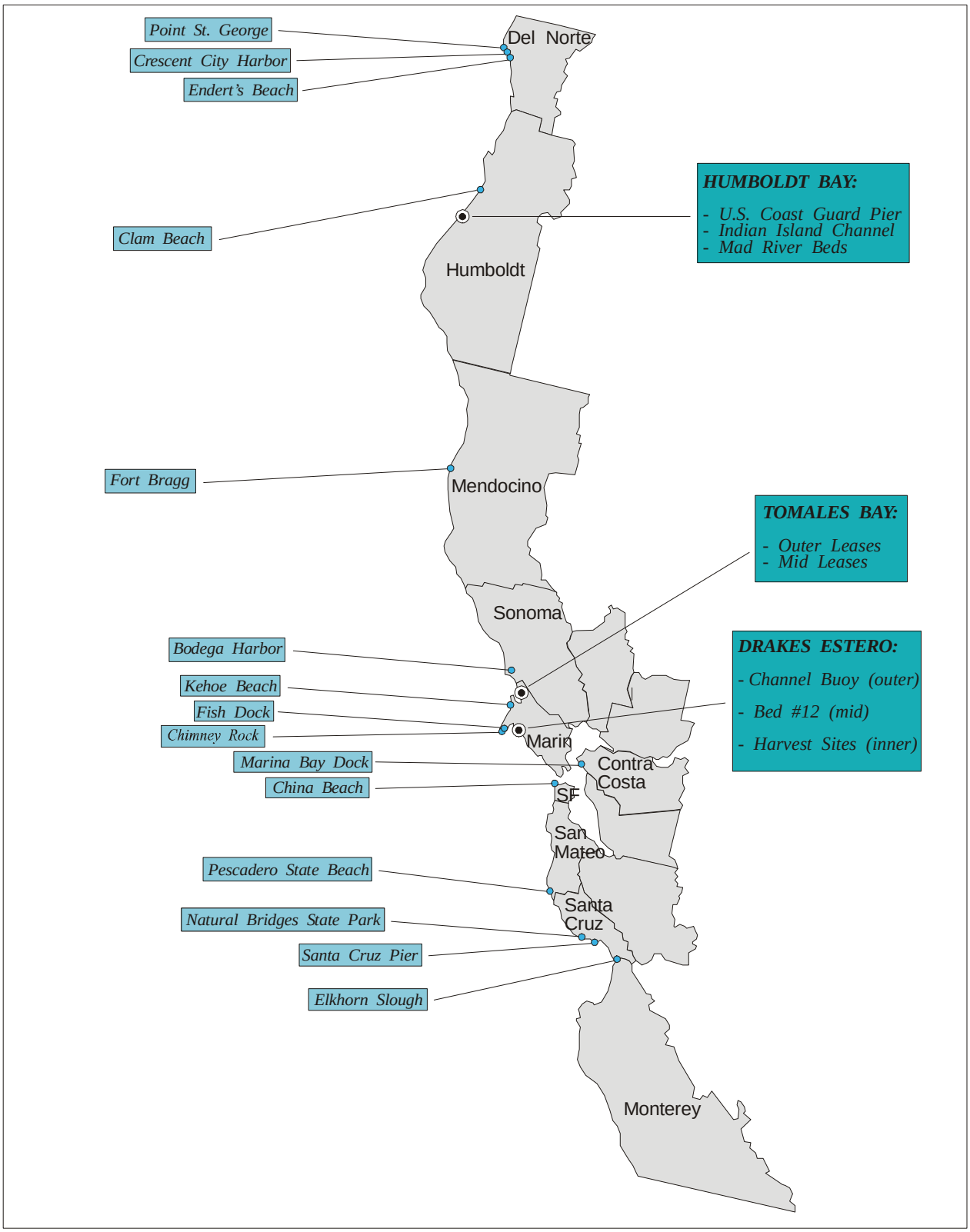

Figure 1b. Locations of shellfish sampling stations during 2005 (San Luis Obispo to San Diego counties).

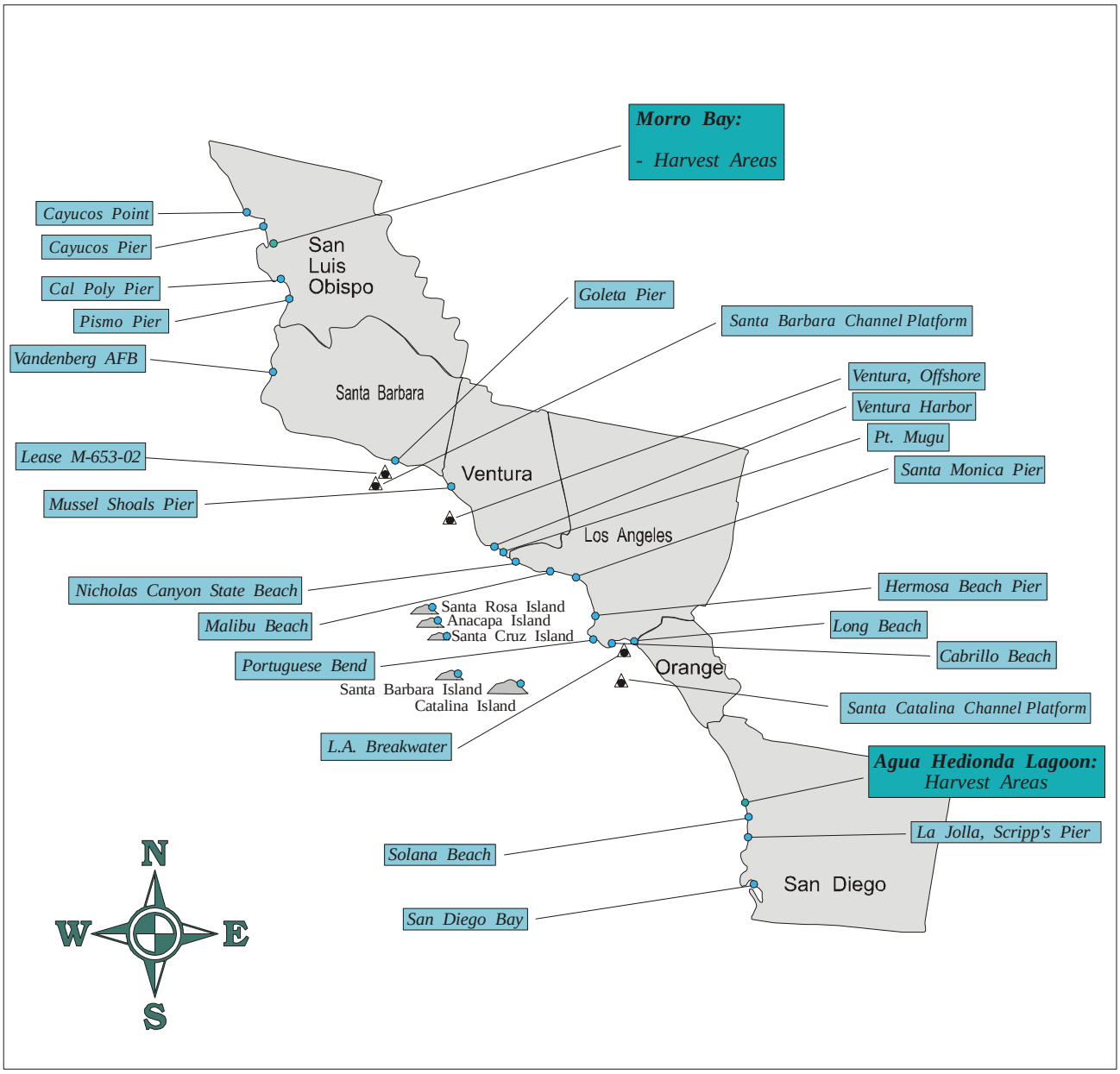

Figure 1c. Locations of phytoplankton sampling stations during 2005 (Del Norte to Monterey counties).

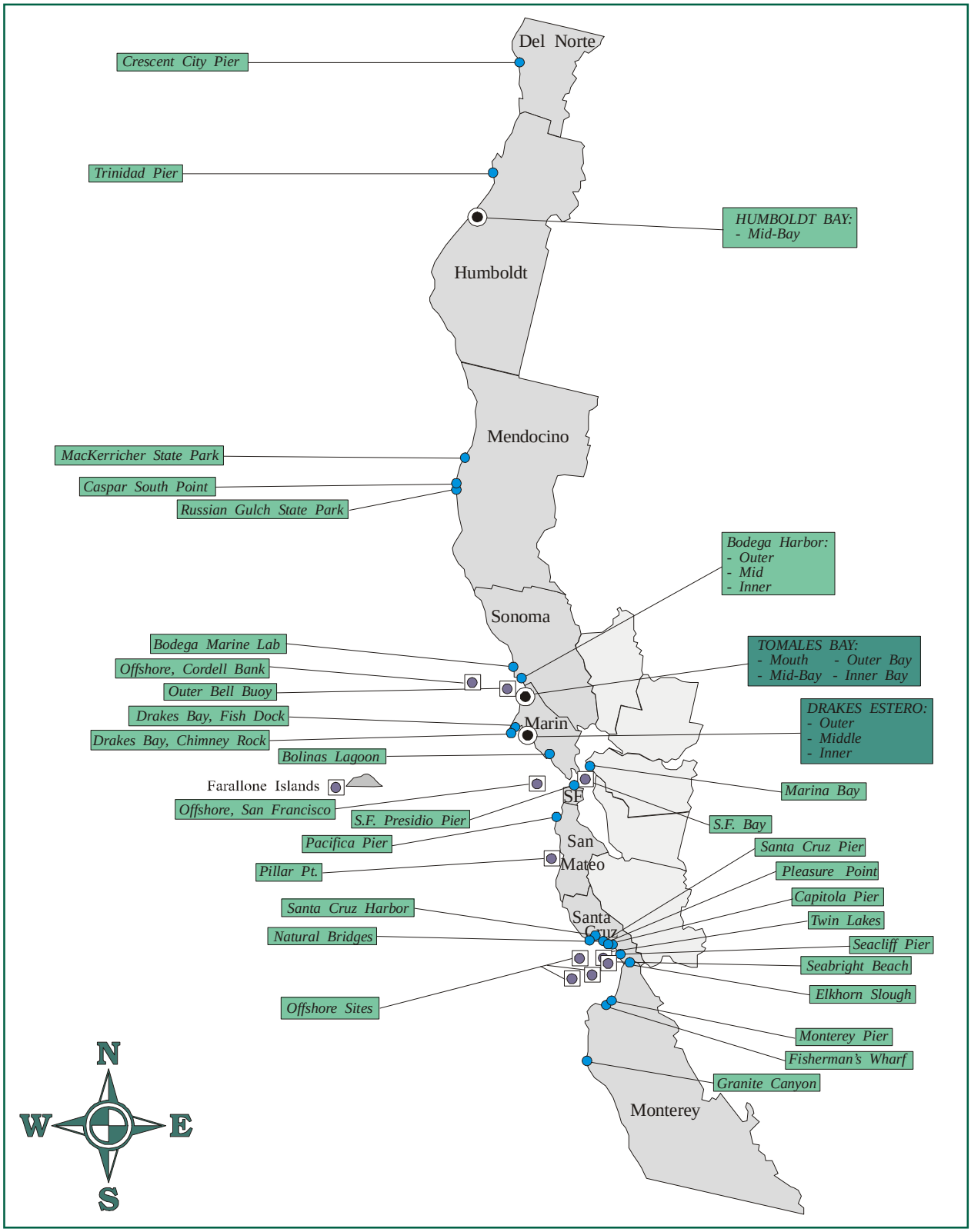

Figure 1d. Locations of phytoplankton sampling stations during 2005 (San Luis Obispo to San Diego counties).

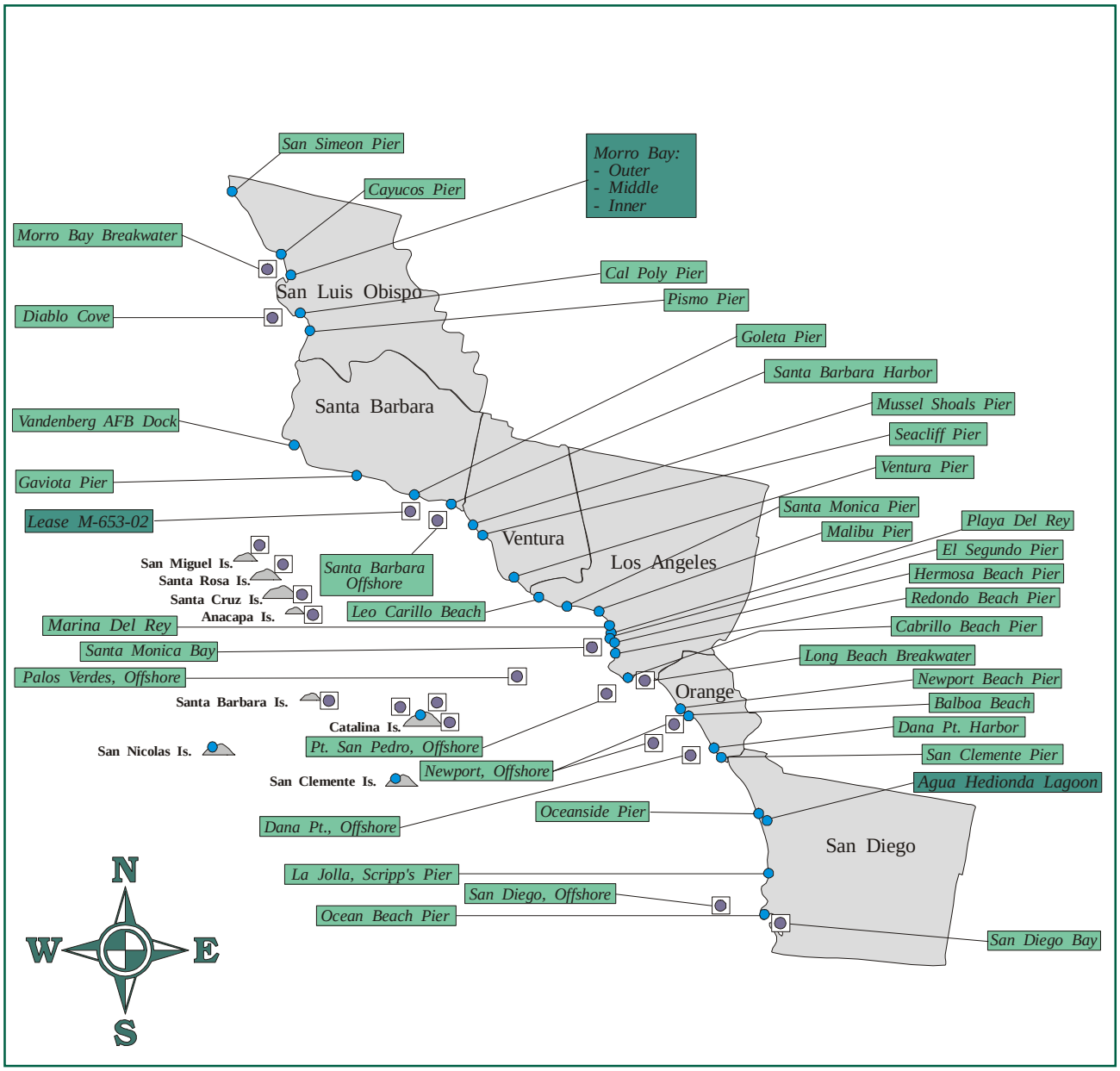

Figure 2. Annual PSP toxin levels in California shellfish from 1991 through 2005.

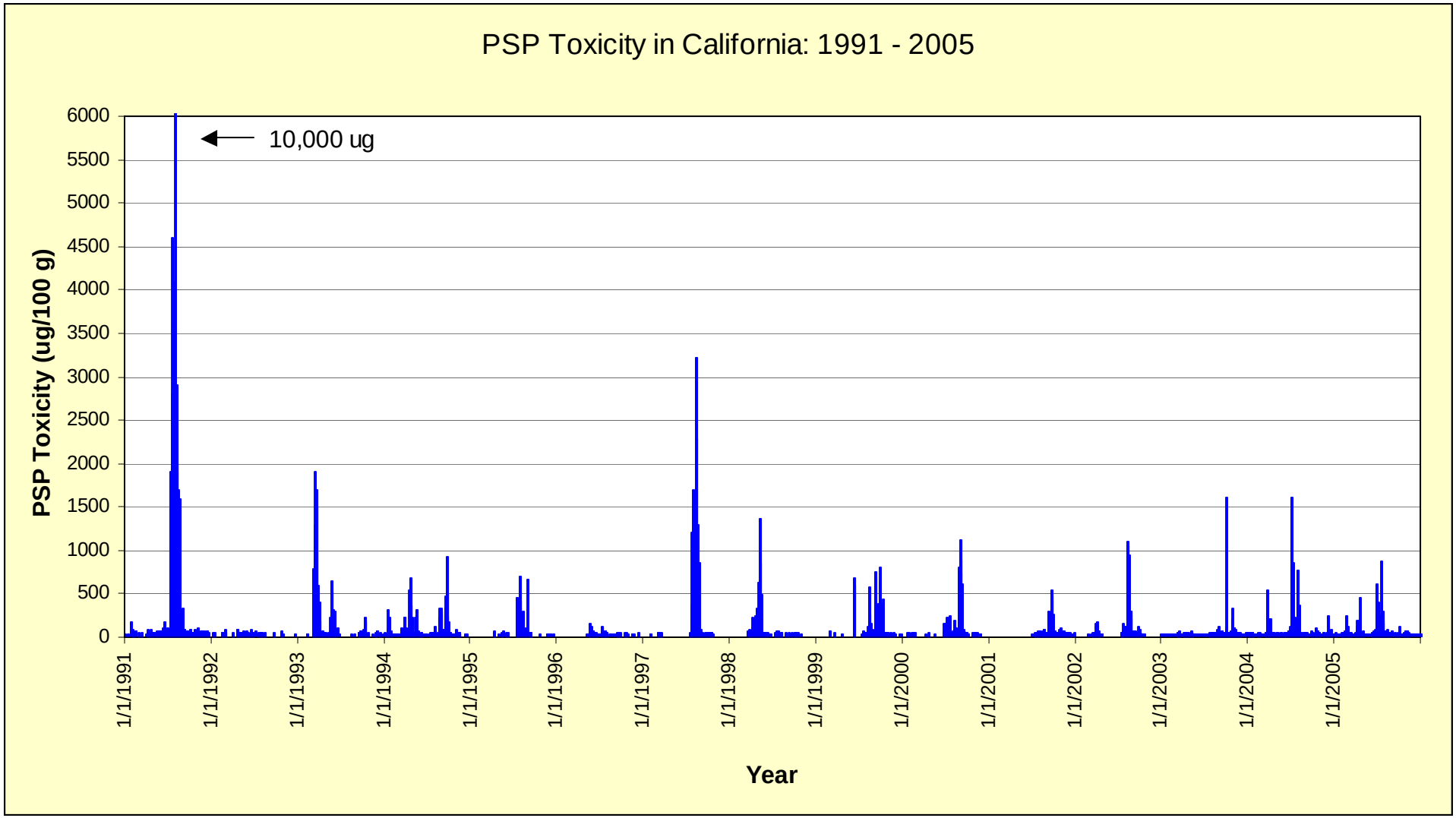

Figure 3. PSP toxin concentration and temporal distribution in California shellfish during 2005.

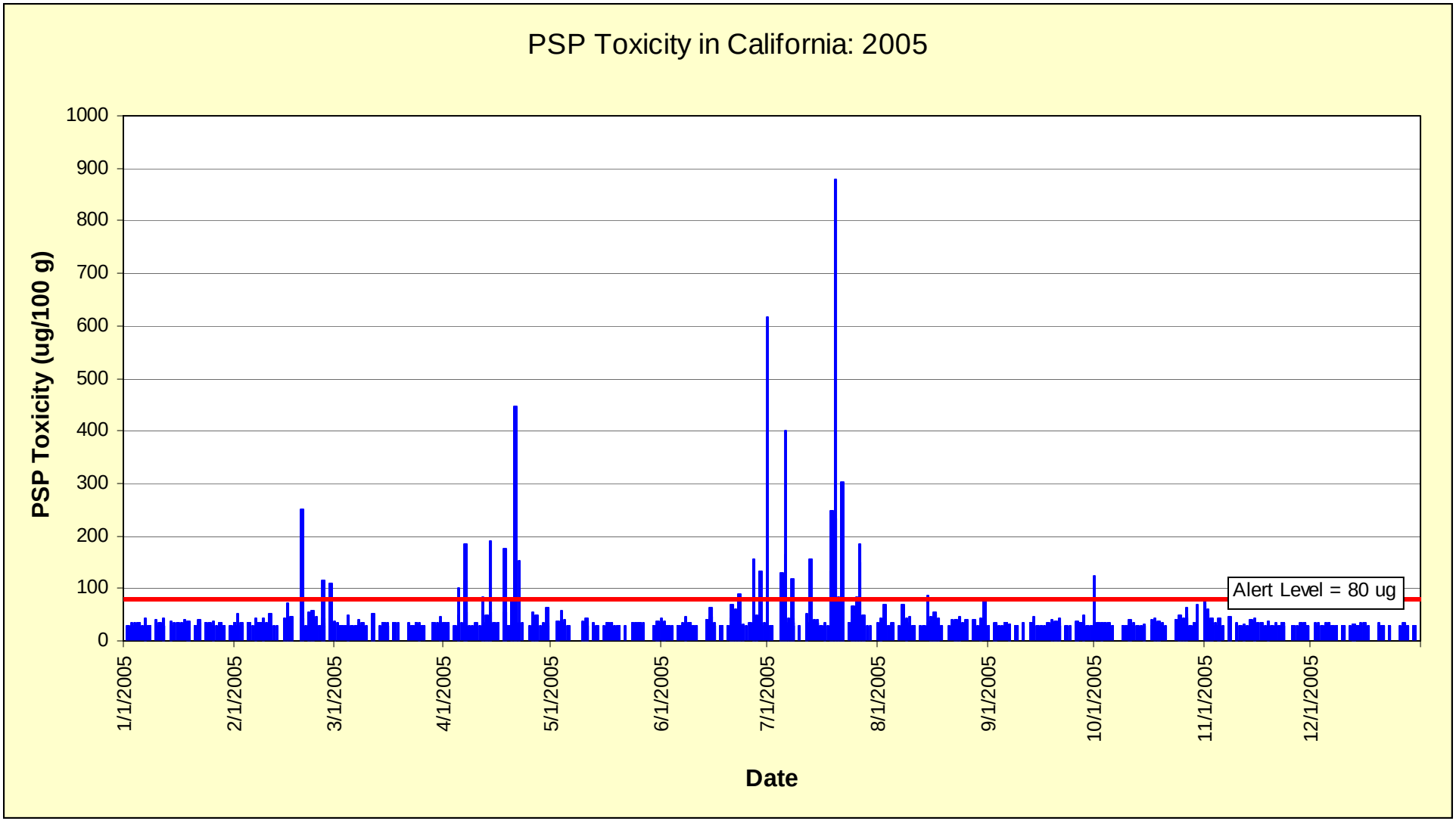

Figure 4. Temporal distribution and percent composition of *Alexandrium spp*. during 2005.

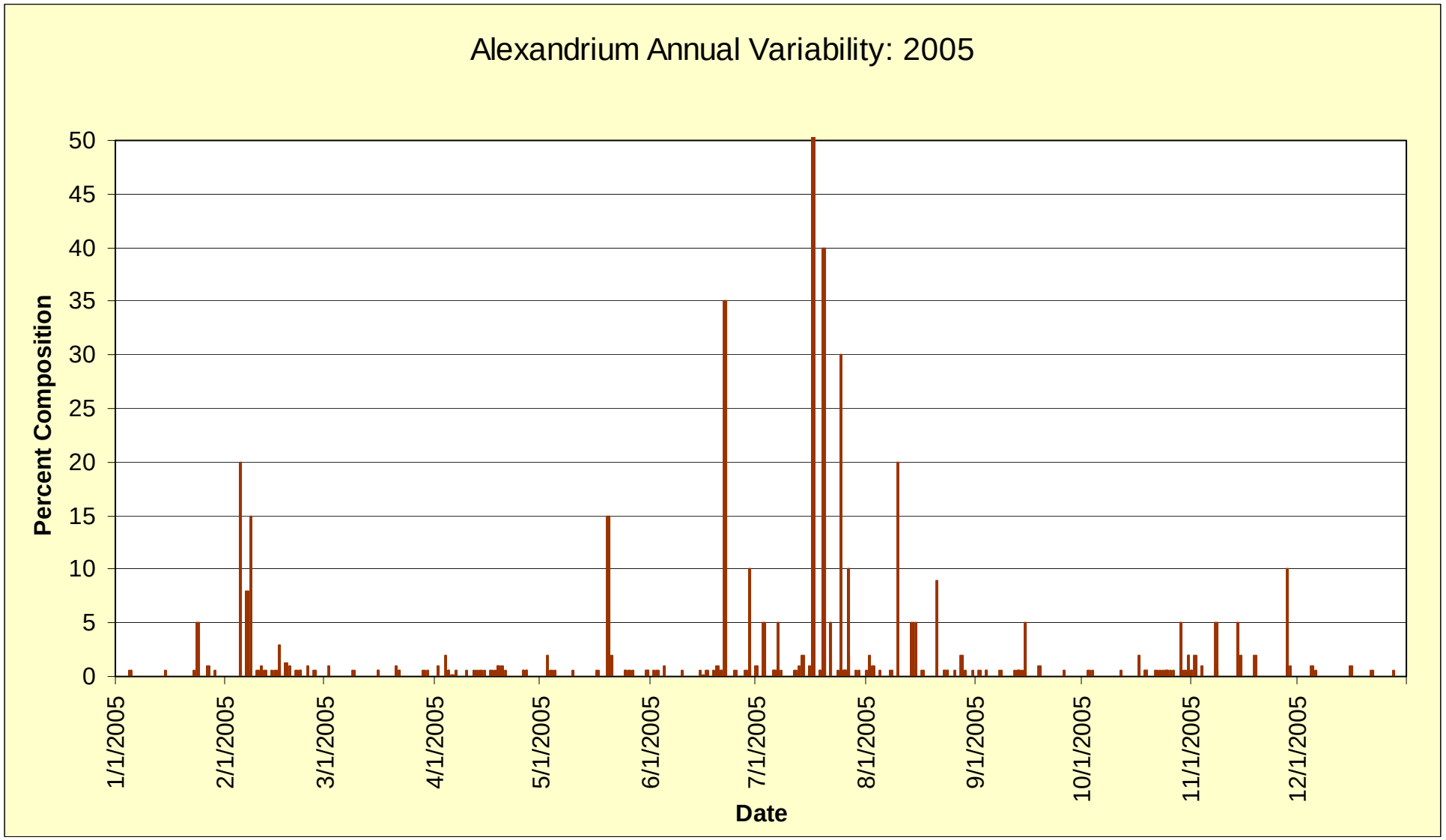

Figure 5. Domoic acid concentration and temporal distribution in California shellfish during 2005.

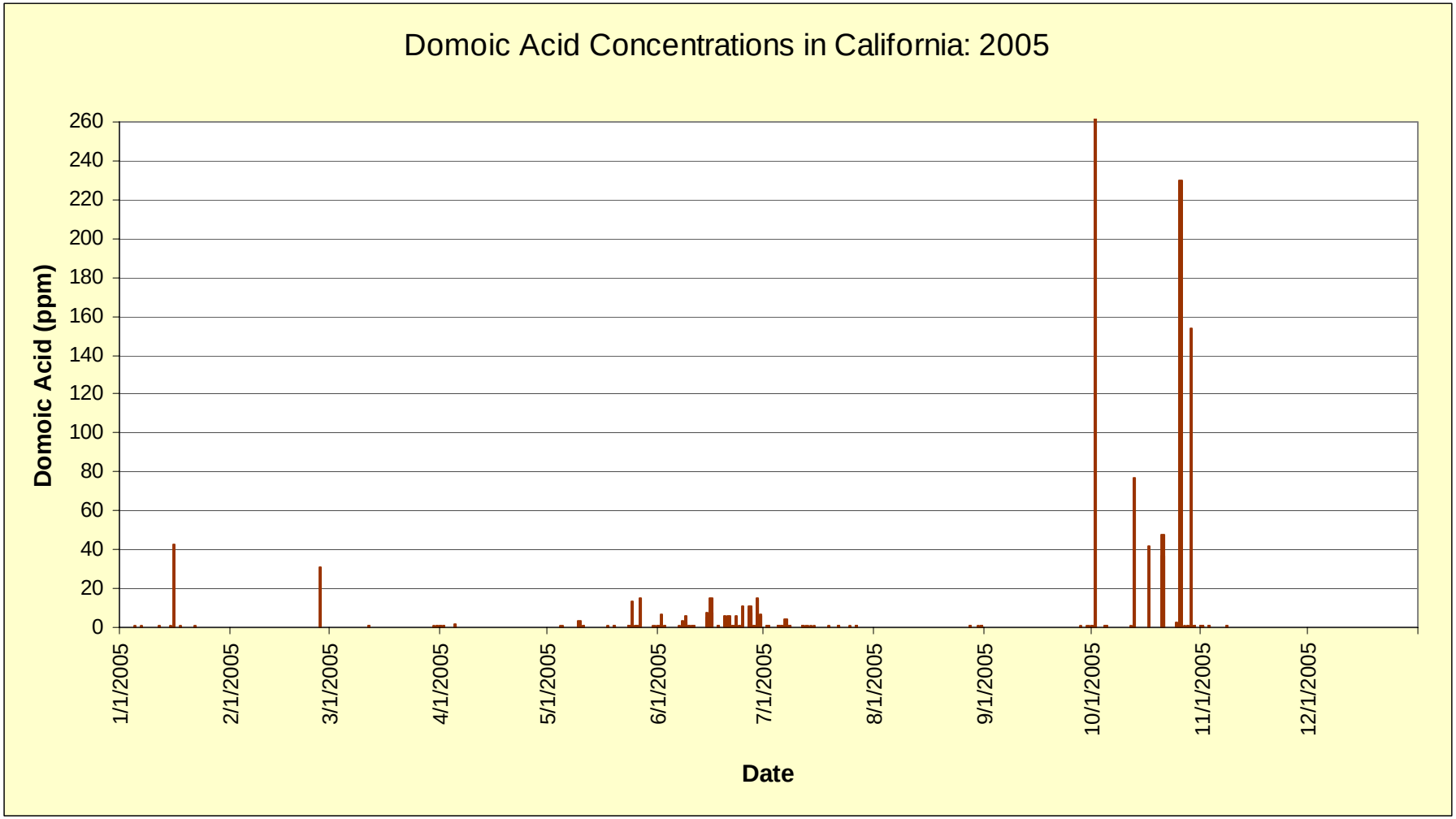

Figure 6. Temporal distribution and percent composition of *Pseudo-nitzschia spp*. during 2005.

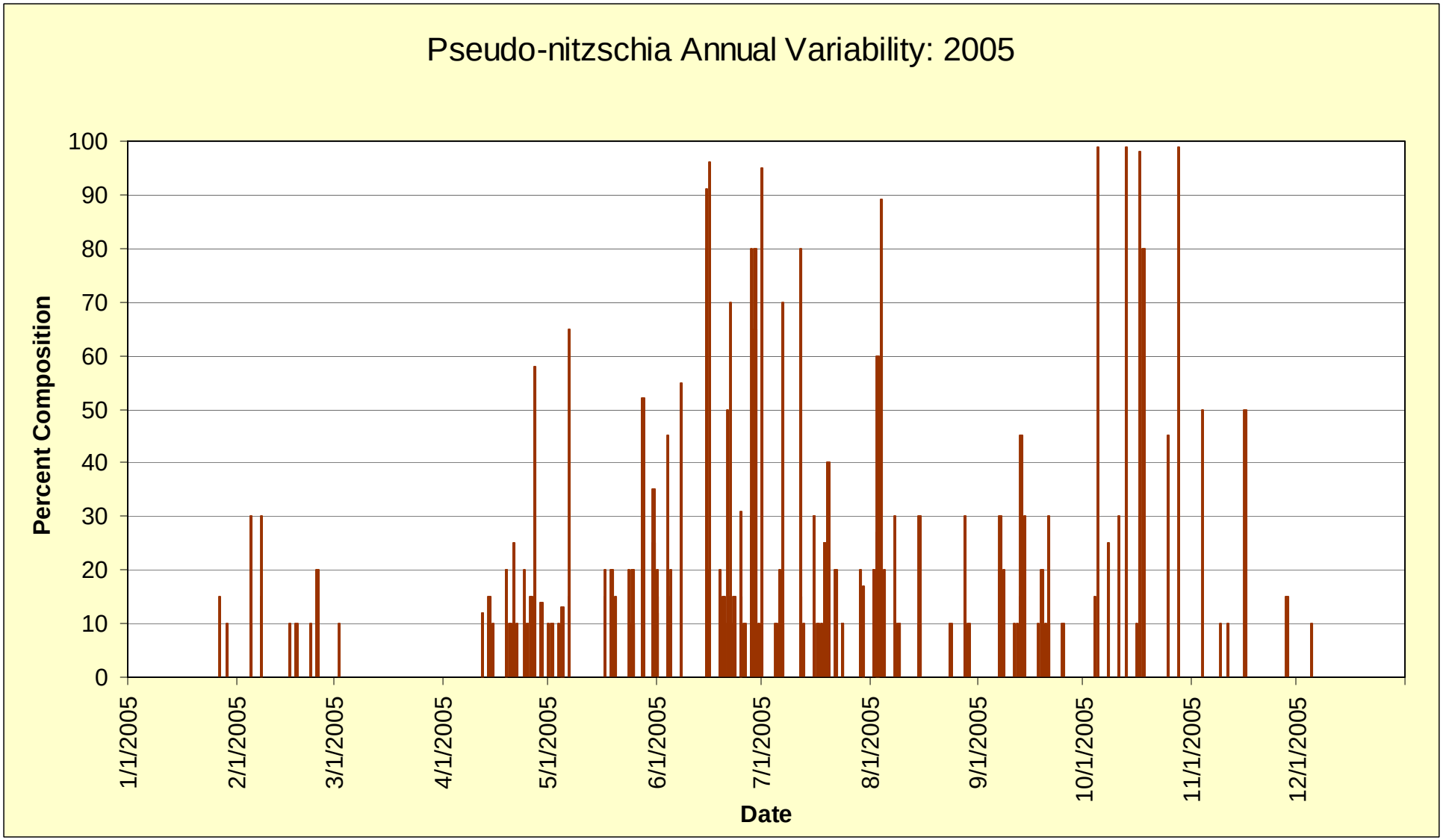

Figure 7. Temporal distribution and relative abundance index (RAI) of *Pseudo-nitzschia spp*. during 2005.